

I claim:

1 1. A frequency and phase synchronizer system, comprising:

2
3 a processor for executing a sequence of operations, which include:

4
5 a) initializing a frequency error estimate value and phase error estimate value;

6
7 b) separating discrete samples of a continuous phase modulation signal into a first
8 sequence of odd numbered samples of said signal, and a second sequence of even
9 numbered samples of said signal;

10
11 c) determining an unknown frequency offset value from said first and second sequences,
12 frequency error estimate, and phase error estimate;

13
14 d) determining an unknown phase offset value from said first and second sequences,
15 frequency error estimate, phase error estimate, and a first discrete data sample of said
16 discrete samples of said continuous phase modulation signal;

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18 e) updating said frequency error estimate from said unknown frequency offset value; and

19
20 f) updating said phase error estimate from said unknown phase offset value.

1 2. The frequency and phase synchronizer system of claim 1 wherein said operations *b* through *f*
2 are repeated an integral number of times.

1 3. The frequency and phase synchronizer system of claim 1 further including a digital receiver

2 for generating a frequency and phase corrected output signal in response to said digital receiver
3 receiving said updated estimated frequency error estimate and said updated estimated phase error
4 estimate

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1 4. The frequency and phase synchronizer system of claim 1 wherein said unknown frequency
2 offset value is determined by:

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4 generating a first product by multiplying said first sequence of even numbered samples by a first
5 parameter;

6

7 generating a first complex exponential value by applying a first discrete time voltage controlled
8 oscillator to said frequency error estimate;

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10 generating a second product by multiplying said first product and said first complex exponential
11 value;

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13 generating a third product by multiplying said second sequence of odd numbered samples by a
14 second parameter;

15

16 generating a second complex exponential value by applying a second discrete time voltage
17 controlled oscillator to said frequency error estimate;

18

19 generating a fourth product by multiplying said third product and said second complex
20 exponential value;

21

22 generating a sequence of first sum signals $SUM1_l$ by adding said second and fourth products,
23 where l is an index and $1 \leq l \leq N$ and N is a positive integer ;

24

25 generating a first accumulated sum $ASUM1$, where $ASUM1 = \sum_1^N SUM1_l$;

26

27 generating a fifth product by multiplying said first accumulated sum $ASUM1$ by a third

28 parameter;

29

30 generating a third complex exponential value in response to receiving said phase error estimate;

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32 generating a sixth product having real and imaginary components by multiplying said third

33 complex exponential value by said fifth product value; and

34

35 equating said unknown frequency offset value to said imaginary component of said sixth product

36 to update said unknown frequency offset value.

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5. The frequency and phase synchronizer system of claim 1 wherein said unknown phase value
is determined by:

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4 generating a seventh product by multiplying said first sequence of even numbered samples by a
5 fourth parameter;

6

7 generating a fourth complex exponential value by applying a third discrete time voltage
8 controlled oscillator to said frequency error estimate;

9

10 generating an eighth product by multiplying said seventh product and said fourth complex
11 exponential value;

12

13 generating a ninth product by multiplying said second sequence of odd numbered samples by a
14 fifth parameter;

15

16 generating a fifth complex exponential value by applying a fourth discrete time voltage
17 controlled oscillator to said frequency error estimate;

18

19 generating a tenth product by multiplying said ninth product and said fifth complex exponential
20 value;

21

22 generating a sequence of second signals $SUM2_l$ by adding said eighth and tenth products, where l
23 is an index and $1 \leq l \leq N$ and N is a positive integer ;

24

25 generating a second accumulated sum $ASUM2$, where $ASUM2 = \sum_1^N SUM2_l$;

26

27 generating an eleventh product by multiplying said second accumulated sum $ASUM2$ by a sixth
28 parameter;

29

30 adding said first discrete data sample to said eleventh product to obtain a third sum value;

31

32 generating a sixth complex exponential value in response to receiving said phase error estimate;

33

34 generating a twelfth product having real and imaginary components by multiplying said sixth
35 complex exponential value by said third sum value; and

36

37 equating said unknown phase offset value to said imaginary component of said twelfth product to
38 update said unknown phase offset value.

1 6. The frequency and phase synchronizer system of claim 1 wherein said step of updating said
2 frequency error estimate uses a time delayed frequency error estimate and a first step-size
3 parameter.

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1 7. The frequency and phase synchronizer system of claim 1 wherein said step of updating said
2 phase error estimate uses a time delayed frequency error estimate and a second step-size
3 parameter.

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1 8. A method for providing frequency and phase synchronization of a continuous phase
2 modulation signal, comprising the steps of:

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- 4 a) initializing a frequency error estimate value and phase error estimate value;
- 5
- 6 b) separating discrete samples of a continuous phase modulation signal into a first sequence of
7 odd numbered samples of said signal, and a second sequence of even numbered samples of said
8 signal;
- 9
- 10 c) determining an unknown frequency offset value from said first and second sequences,
11 frequency error estimate, and phase error estimate;
- 12
- 13 d) determining an unknown phase offset value from said first and second sequences, frequency
14 error estimate, phase error estimate, and a first discrete data sample of said discrete samples of
15 said continuous phase modulation signal;
- 16
- 17 e) updating said frequency error estimate from said unknown frequency offset value; and
- 18
- 19 f) updating said phase error estimate from said unknown phase offset value.

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- 1 9. The method of claim 8 wherein said unknown frequency offset value is determined by:
- 2
- 3 generating a first product by multiplying said first sequence of even numbered samples by a first
- 4 parameter;
- 5
- 6 generating a first complex exponential value by applying a first discrete time voltage controlled
- 7 oscillator to said frequency error estimate;
- 8
- 9 generating a second product by multiplying said first product and said first complex exponential
- 10 value;
- 11
- 12 generating a third product by multiplying said second sequence of odd numbered samples by a
- 13 second parameter;
- 14
- 15 generating a second complex exponential value by applying a second discrete time voltage
- 16 controlled oscillator to said frequency error estimate;
- 17
- 18 generating a fourth product by multiplying said third product and said second complex
- 19 exponential value;
- 20
- 21 generating a sequence of first sum signals $SUM1_l$ by adding said second and fourth products,
- 22 where l is an index and $1 \leq l \leq N$ and N is a positive integer ;
- 23
- 24 generating a first accumulated sum $ASUM1$, where $ASUM1 = \sum_1^N SUM1_l$;
- 25
- 26 generating a fifth product by multiplying said first accumulated sum $ASUM1$ by a third

27 parameter;
28
29 generating a third complex exponential value in response to receiving said phase error estimate;
30
31 generating a sixth product having real and imaginary components by multiplying said third
32 complex exponential value by said fifth product value; and
33
34 equating said unknown frequency offset value to said imaginary component of said sixth product
35 to update said unknown frequency offset value.

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10. The method of claim 8 wherein said unknown phase value is determined by:

2

3 generating a seventh product by multiplying said first sequence of even numbered samples by a
4 fourth parameter;

5

6 generating a fourth complex exponential value by applying a third discrete time voltage
7 controlled oscillator to said frequency error estimate;

8

9 generating an eighth product by multiplying said seventh product and said fourth complex
10 exponential value;

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12 generating a ninth product by multiplying said second sequence of odd numbered samples by a
13 fifth parameter;

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15 generating a fifth complex exponential value by applying a fourth discrete time voltage
16 controlled oscillator to said frequency error estimate;

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18 generating a tenth product by multiplying said ninth product and said fifth complex exponential
19 value;

20

21 generating a sequence of second signals $SUM2_l$ by adding said eighth and tenth products, where l
22 is an index and $1 \leq l \leq N$ and N is a positive integer ;

23

24 generating a second accumulated sum $ASUM2$, where $ASUM2 = \sum_1^N SUM2_l$;

25

26 generating an eleventh product by multiplying said second accumulated sum $ASUM2$ by a sixth
27 parameter;

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29

30 adding said first discrete data sample to said eleventh product to obtain a third sum value;

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34 generating a sixth complex exponential value in response to receiving said phase error estimate;

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37 generating a twelfth product having real and imaginary components by multiplying said sixth
complex exponential value by said third sum value; and

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2 13. A computer program product, comprising:

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4 a computer usable medium having a computer readable program code embedded therein for
5 causing a computer to execute a sequence of operations which include:

6
7 a) initializing a frequency error estimate value and phase error estimate value;

8
9 b) separating discrete samples of a continuous phase modulation signal into a first
10 sequence of odd numbered samples of said signal, and a second sequence of even
11 numbered samples of said signal;

12
13 c) determining an unknown frequency offset value from said first and second sequences,
14 frequency error estimate, and phase error estimate;

15
16 d) determining an unknown phase offset value from said first and second sequences,
17 frequency error estimate, phase error estimate, and a first discrete data sample of said
18 discrete samples of said continuous phase modulation signal;

19
20 e) updating said frequency error estimate from said unknown frequency offset value; and

21
22 f) updating said phase error estimate from said unknown phase offset value.

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2 14. The method of claim 13 wherein said sequence of operations for determining said unknown
3 frequency offset value include:

4 generating a first product by multiplying said first sequence of even numbered samples by a first

5 parameter;

6

7 generating a first complex exponential value by applying a first discrete time voltage controlled

8 oscillator to said frequency error estimate;

9

10 generating a second product by multiplying said first product and said first complex exponential

11 value;

12

13 generating a third product by multiplying said second sequence of odd numbered samples by a

14 second parameter;

15

16 generating a second complex exponential value by applying a second discrete time voltage

17 controlled oscillator to said frequency error estimate;

18

19 generating a fourth product by multiplying said third product and said second complex

20 exponential value;

21

22 generating a sequence of first sum signals $SUM1_l$ by adding said second and fourth products,

23 where l is an index and $1 \leq l \leq N$ and N is a positive integer ;

24

25 generating a first accumulated sum $ASUM1$, where $ASUM1 = \sum_1^N SUM1_l$;

26

27 generating a fifth product by multiplying said first accumulated sum $ASUM1$ by a third

28 parameter;

29

30 generating a third complex exponential value in response to receiving said phase error estimate;

31
32 generating a sixth product having real and imaginary components by multiplying said third
33 complex exponential value by said fifth product value; and
34
35 equating said unknown frequency offset value to said imaginary component of said sixth product
36 to update said unknown frequency offset value.

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1 15. The method of claim 13 wherein said sequence of operations for determining said
2 unknown phase value include:

3
4 generating a seventh product by multiplying said first sequence of even numbered samples by a
5 fourth parameter;

6
7 generating a fourth complex exponential value by applying a third discrete time voltage
8 controlled oscillator to said frequency error estimate;

9
10 generating an eighth product by multiplying said seventh product and said fourth complex
11 exponential value;

12
13 generating a ninth product by multiplying said second sequence of odd numbered samples by a
14 fifth parameter;

15
16 generating a fifth complex exponential value by applying a fourth discrete time voltage
17 controlled oscillator to said frequency error estimate;

18
19 generating a tenth product by multiplying said ninth product and said fifth complex exponential
20 value;

21 generating a sequence of second signals $SUM2_l$ by adding said eighth and tenth products, where l
22 is an index and $1 \leq l \leq N$ and N is a positive integer ;
23

24 generating a second accumulated sum $ASUM2$, where $ASUM2 = \sum_1^N SUM2_l$;
25

26 generating an eleventh product by multiplying said second accumulated sum $ASUM2$ by a sixth
27 parameter;
28

29 adding said first discrete data sample to said eleventh product to obtain a third sum value;
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31

32 generating a sixth complex exponential value in response to receiving said phase error estimate;
33

34 generating a twelfth product having real and imaginary components by multiplying said sixth
35 complex exponential value by said third sum value; and
36

37 equating said unknown phase offset value to said imaginary component of said twelfth product to
38 update said unknown phase offset value.

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1 16. The method of claim 13 wherein said sequence of operations for updating said frequency
2 error estimate uses a time delayed frequency error estimate and a first step-size parameter.
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1 17. The method of claim 13 wherein said sequence of operations for updating said phase error
2 estimate uses a time delayed frequency error estimate and a second step-size parameter.
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